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In the Clinic®

Management of Hyperglycemia in Hospitalized Patients

Diagnosis

Treatment

People with diabetes account for 25% of hospitalizations, or 8 million admissions annually. Poor glycemic control in the hospital is associated with increased morbidity, mortality, length of stay, and readmissions. Key considerations of inpatient diabetes management include initiation of appropriate insulin or medication regimens and frequent dose adjustments based on patient-specific factors. Inpatient diabetes management teams and new technologies are increasingly prevalent and can assist in achieving glycemic targets in the hospital. At discharge, standardized checklists should be used to ensure successful transitions of care.

CME/MOC activity available at Annals.org.

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An estimated 37 million people in the United States have diabetes (1). Although people with diabetes represent just over 11% of the U.S. population, they account for more than 25% of hospitalizations, or 8 million annually (1). These hospitalizations are associated with more complications, greater length of stay (LOS), and increased morbidity and mortality (2). Moreover, after hospital discharge, patients with diabetes have twice the risk for readmission of those without diabetes, with about 20% being readmitted within 30 days and 30% within 1 year (3).

These increased risks are not limited to patients with diabetes. Hyperglycemia in hospitalized patients with or without diabetes is a predictor of worse outcomes (4, 5). Hyperglycemia is associated with higher rates of intensive care unit (ICU) admission and death among patients hospitalized with infections, such as community-acquired pneumonia or COVID-19 pneumonia (6). Similarly, worse outcomes are noted among patients with acute myocardial infarction, cerebrovascular accident, or acute renal failure (7). In surgical patients, poor glycemic control leads to impaired wound healing, increased infections, increased LOS, and mortality (8).

Whether high blood glucose (BG) levels are directly responsible for worse outcomes or simply a marker of increased disease burden and end-organ dysfunction is unclear. Hyperglycemia is known to directly impair immune function, increase inflammation, and affect volume status. Yet studies investigating intensive versus liberal inpatient glycemic targets have not found differences in morbidity or mortality (9). Thus, hyperglycemia is likely both a marker of illness severity and potentially a direct contributor to worse health outcomes.

Diagnosis

What are the definitions of inpatient hyperglycemia and hypoglycemia?

In non–critically ill patients, hyperglycemia is defined as a BG level above 140 mg/dL (>7.8 mmol/L) and occurs in up to 25% of inpatients. Stress hyperglycemia or hospital-induced hyperglycemia refers to hyperglycemia in patients without diabetes (10–12). Hypoglycemia is defined as a BG level below 70 mg/dL (<3.9 mmol/L) and is further stratified by intensity. Level 1 hypoglycemia is defined as a BG level of 54 to 69 mg/dL (3.0 to 3.8 mmol/L); level 2 is defined as a BG level below 54 mg/dL and is associated with neuroglycopenic symptoms, such as weakness, confusion, or fatigue. Level 3 hypoglycemia is defined as a BG level associated with cognitive changes requiring assistance for recovery. Levels 1 and 2 must be treated to prevent level 3 hypoglycemia (10). In addition, the Centers for Medicare & Medicaid Services recently defined a BG level below 40 mg/dL (<2.2 mmol/L) resulting from diabetes treatment as a reportable inpatient quality measure (13).

Guidelines from the American Diabetes Association, the American Association of Clinical Endocrinology, and the Endocrine Society recommend checking a hemoglobin A_{1c} (HbA_{1c}) level on admission in every patient with hyperglycemia in the hospital if not checked within the prior 3 months. In patients without known diabetes, it helps to differentiate stress hyperglycemia from undiagnosed diabetes (10–12). Patients with diabetes or those with a BG level over 140 mg/dL should have point-of-care (POC) BG testing before meals and at bedtime if they are eating and every 4 to 6 hours if they are nil per os (NPO) or are receiving continuous nutrition (for example, tube feeds or parenteral nutrition [PN]) (10–12).

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What is an optimal glycemic target for hospitalized patients?

Noncritical illness

For non–critically ill patients, the recommended glycemic target is 100 to 180 mg/dL (5.6 to 10.0 mmol/L) (10, 11). Glycemic treatment should be initiated or modified if the BG level is above 180 mg/dL more than twice in 24 hours. Higher BG goals (up to 250 mg/dL [13.9 mmol/L]) may be appropriate for patients with significant comorbidities, those at high risk for hypoglycemia (for example, end-stage renal disease, hypoglycemia unawareness), or those with terminal illness (10). The recommended preprandial BG target is 100 to 140 mg/dL, and the postprandial target is below 180 mg/dL (12, 14). In hospitalized patients being treated for hyperglycemia, a fasting BG level below 100 mg/dL portends hypoglycemia and requires modification of the diabetes treatment regimen (10).

Critical illness

For most patients with hyperglycemia in the ICU, the recommended BG target is 140 to 180 mg/dL (10); however, recent studies suggest that higher targets (up to 215 mg/dL [11.9 mmol/L]) may be acceptable for certain populations, such as those not receiving PN (15). In the postoperative setting (especially cardiac surgery), more stringent goals (110 to 140 mg/dL [6.1 to 7.8 mmol/L]) may be appropriate if they can be achieved without increasing risk for hypoglycemia (10). Growing evidence suggests that outcomes may be improved in critically ill patients by individualizing BG goals on the basis of preadmission BG levels (16).

A randomized controlled trial (RCT) of postsurgical ICU patients showed that intensive insulin therapy with a BG target of 80 to 110 mg/dL (4.4 to 6.1 mmol/L) improved morbidity and mortality (17). These findings could not be reproduced in other large trials. The NICE-SUGAR trial, a large international study, randomly assigned medical ICU patients to receive insulin infusion with an intensive BG target of 81 to 108 mg/dL (4.5 to 6.0 mmol/L) and a conventional BG target of less than 180 mg/dL. The intensive group was shown to have higher 90-day mortality than the conventional group (27.5% vs. 24.9%; P = 0.02) (18).

Diagnosis... Hyperglycemia in hospitalized patients, independent of diabetes history, is associated with poor outcomes. Hospital hyperglycemia is defined as a BG level above 140 mg/dL, and hypoglycemia is defined as a BG level below 70 mg/dL. Stress hyperglycemia is defined as a BG level above 140 mg/dL without a prior diagnosis of diabetes. Glycemic treatment should be initiated if the BG level remains above 180 mg/dL. Recommended BG targets are 100 to 180 mg/dL for most non–critically ill patients and 140 to 180 mg/dL for critically ill patients. More liberal targets (such as <250 mg/dL) may be appropriate for patients at high risk for hypoglycemia.

CLINICAL BOTTOM LINE

Treatment

What is the best way to treat hyperglycemia in a hospitalized patient?

Insulin remains the gold standard for management of hospital hyperglycemia. For stress hyperglycemia, correction scale insulin should be added when BG values are over 140 mg/dL (11). If the BG level is at or above 180 mg/dL more than twice in 24 hours despite correction scale insulin, initiation of scheduled insulin and/or oral medications is recommended (11, 12). For patients with relatively well-controlled diabetes (HbA_{1c} level <8%) on noninsulin regimens before admission, an initial correction scale may be adequate (12, 19). However, if the BG level is above

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200 mg/dL (>11.1 mmol/L) at presentation, scheduled insulin or a noninsulin agent should be started (19). Treatment should be intensified if the BG level stays above 180 mg/dL (19). Most patients receiving insulin before admission should be started on scheduled insulin therapy, although the dosing may need to be modified based on the patient's clinical condition (19).

The optimal regimen for non–critically ill patients with good nutritional intake is administration of basal, prandial, and correction scale insulin (10–12, 20, 21).

Two large RCTs (RABBIT-2 [20] and RABBIT-2 Surgery [21]) reported that scheduled basal, bolus, and correction scale insulin was superior to correction scale insulin alone in achieving BG goals and improving clinical outcomes. RABBIT-2 Surgery found lower incidence of complications, including wound infection, pneumonia, bacteremia, respiratory failure, and acute renal failure, in the basal–bolus cohort compared with the correction scale cohort. Rates of mild hypoglycemia were higher in the basal–bolus group in RABBIT-2 Surgery but not RABBIT-2, whereas rates of severe hypoglycemia did not differ between groups.

Basal insulins are long-acting insulins (for example, glargine) given a maximum of 2 times daily. Neutral protamine Hagedorn (NPH) insulin, an intermediate-acting insulin, is an alternative basal insulin that covers basal needs when administered twice daily. NPH is not preferred to glargine as it has a pronounced peak and trough. Patients with type 1 diabetes (T1D) must receive some form of basal insulin (such as long-acting subcutaneous insulin, insulin pump, or insulin infusion) to prevent diabetic ketoacidosis (DKA) (10). Prandial insulins are rapid-acting insulins (for example, lispro, aspart) that are timed with food (**Appendix Table**, available at Annals.org). The preprandial POC BG level should be checked and prandial insulin should be given up to 15 minutes before or within 20 to 30 minutes after the start of a meal (10, 22). In patients with inconsistent oral intake, giving the prandial insulin after the meal may be preferred to avoid inadvertent hypoglycemia. Alternatively, a "basal-plus" strategy with basal plus correction scale insulin may be used (10, 23). In patients with T1D and in some patients with type 2 diabetes (T2D) who require insulin, the preferred option is to dose prandial insulin using an insulin-to-carbohydrate ratio based on the number of carbohydrates consumed (10, 11).

A correction scale specifies the dose of rapid-acting insulin that should be administered to bring an elevated BG level back into the target range. To simplify nursing workflow and minimize the number of injections, the type of correctional insulin should be the same as that of the prandial insulin. If the patient is NPO, correction scale insulin alone can be administered as lispro or aspart every 4 hours or as regular insulin every 6 hours (24, 25).

Premixed insulin formulations (such as NPH/regular insulin 70/30) are generally not recommended for inpatients as they carry a 3-fold increased risk for hypoglycemia, especially when given without a meal (26). Premixed insulin should never be used at bedtime, and doses need to be reduced if the patient is NPO.

What is the optimal approach to selecting an initial insulin dose?

Initial insulin dosing for a hospitalized patient is based on the total home insulin dose, a weight-based insulin dose, or the sum of correction insulin given over 24 hours (**Figures 1** and **2**) (11, 19).

For a weight-based approach, the total daily dose (TDD) of insulin is calculated as 0.2 to 0.6 units/kg/d divided into half basal and half prandial insulin (12, 19, 27). A lower starting TDD of 0.2 to 0.25 units/kg/d is recommended for patients who are elderly, are insulin-naive, or have impaired kidney function (estimated glomerular filtration rate

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Figure 1. **Initiation of subcutaneous insulin.**

Step 1: Calculate a TDD using any of the strategies below.

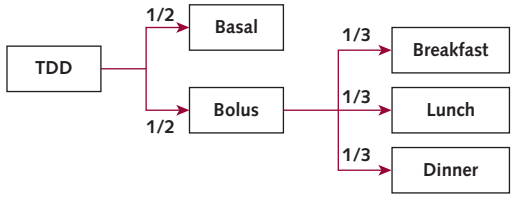
A. Based on prior home dose:
- Add all of the insulin that the patient typically uses at home over the course of 24 hours (mealtime and basal) to calculate TDD.
- Use 75% of home TDD, especially for the following circumstances: NPO status, poor appetite, acute kidney injury, high baseline basal requirement (e.g., >0.5 units/kg/d).

B. Based on weight:
- **TDD 0.2–0.3 units/kg/d:** For patients at increased risk for hypoglycemia, including elderly patients (aged >70 years), patients with renal dysfunction (eGFR <45 mL/min/1.73 m²), or patients with poor oral intake
- **TDD 0.4 units/kg/d:** For standard patients with diabetes (T1D or T2D)
- **TDD 0.5 units/kg/d:** For insulin-resistant patients, including those with obesity (body mass index >30 kg/m²), those using corticosteroids, and those with perioperative stress or infection

C. Based on insulin infusion rate:
- Once the patient has had a stable insulin infusion rate (fluctuating within 0.5 units/h) for a minimum of 3 to 4 hours, the TDD can be calculated by multiplying the average infusion rate over the past 3 to 4 hours by 24.
- Note: In situations where concomitant dextrose-containing IV fluids, steroids, or continuous enteral nutrition or parenteral nutrition may be discontinued simultaneously with IV insulin, the authors do **not** recommend this strategy to calculate TDD.

D. Based on correctional scale insulin:
- If the patient has been on an ICS only, the TDD is calculated by adding all of the doses of correctional insulin received over the past 24 hours.

Step 2: Split the TDD evenly into basal and bolus insulin doses.



Step 3: Add correction scale insulin. An example ICS is shown below.

Blood Glucose Level, *mg/dL*	Low-Intensity ICS	Moderate-Intensity ICS	High-Intensity ICS
	• TDD <40 units/d • eGFR <35 mL/min/1.73 m² or HD • Elderly • Lean • Malnourished • Insulin-naive	• TDD 40–80 units/d • Normal body habitus • Typical T2D	• TDD >80 units/d • Insulin resistance • High steroid dose
70–150	0 units	0 units	0 units
151–200	0 units	2 units	3 units
201–250	2 units	4 units	6 units
251–300	3 units	6 units	9 units
301–350	4 units	8 units	12 units
>350	5 units	10 units	15 units

NOTE: Bedtime correction scale insulin should be half the dose of prandial correction scale insulin.

Adapted from Kim S, Rushakoff RJ, Sullivan M, et al. Hyperglycemia control of the nil per os patient in the intensive care unit: introduction of a simple subcutaneous insulin algorithm. J Diabetes Sci Technol. 2012;6:1413-1419, with permission. Licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License (http://creativecommons.org/licenses/by-nc-sa/4.0). eGFR = estimated glomerular filtration rate; HD = hemodialysis; ICS = insulin correction scale; IV = intravenous; NPO = nil per os; T1D = type 1 diabetes; T2D = type 2 diabetes; TDD = total daily dose.

[eGFR] <45 mL/min/1.73 m^2) (12). Patients with significant obesity, poorly controlled diabetes, or steroid-induced hyperglycemia may need higher initial doses, keeping in mind that TDD greater than 0.6 units/kg/d is associated with increased risk for hypoglycemia (11, 28, 29) (Appendix Figure 1, available at Annals.org).

For patients using insulin before admission, a weight-based calculation is still acceptable as hospital diet and activity levels are different than at home. Alternatively, the home insulin regimen can be modified based on preadmission glycemic control (recent HbA_{1c} or glucose monitoring data), severity of illness, and nutrition and renal status. A 25% or greater reduction in TDD of insulin is prudent for patients with poor oral intake. This is particularly pertinent for preadmission regimens that are "basal-heavy," defined as basal insulin doses of at least 0.6 to 1.0 units/kg/d (where the basal insulin is inappropriately used to cover postprandial BG excursions with minimal or no concurrent nutritional insulin) (12).

How should clinicians adjust insulin doses for hospitalized patients?

Insulin adjustments must account for changes in the patient's clinical status, nutritional intake, renal function, infection, medications, and steroid dose changes. In addition, incorrect data (for example, glucose improperly checked postprandially rather than preprandially) or improperly held insulin doses

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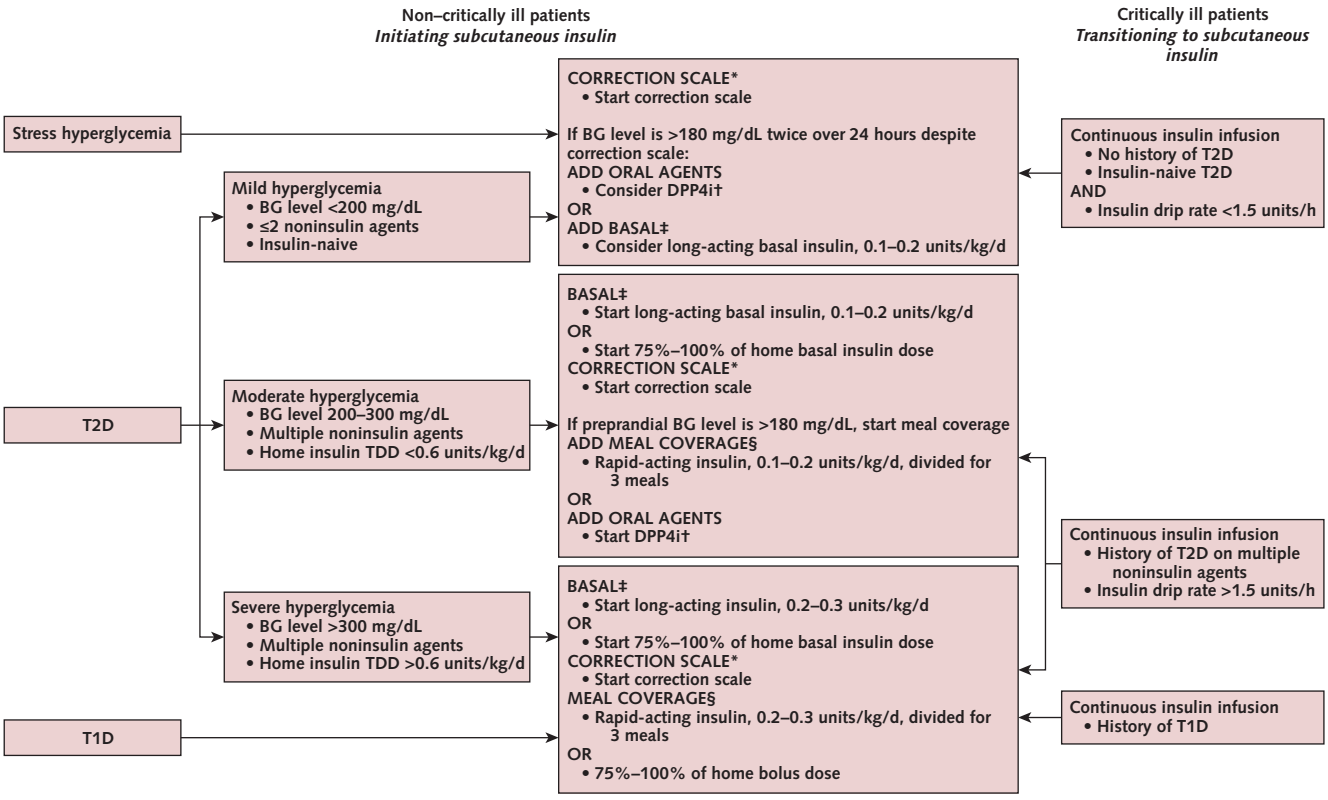
Figure 2. **Overview of recommendations for subcutaneous insulin initiation.**



Data from references 24 and 39. BG = blood glucose; DPP4i = dipeptidyl peptidase-4 inhibitor; T1D = type 1 diabetes; T2D = type 2 diabetes; TDD = total daily dose.
* If the patient is eating, correction scale insulin should be given as rapid-acting insulin before meals and at bedtime. If the patient is not eating, correction scale insulin should be given as short-acting regular or rapid-acting insulin every 4 to 6 hours.
† DPP4i can be given as linagliptin, 5 mg/d, or sitagliptin with dose based on estimated glomerular filtration rate (e.g., ≥45 mL/min/1.73 m^2 = 100 mg/d, 30 to 44 mL/min/1.73 m^2 = 50 mg/d, <30 mL/min/1.73 m^2 = 25 mg/d).
‡ Basal insulin can be once- or twice-daily long-acting insulin.
§ If the patient is not eating, meal coverage should be held, using basal insulin and correction scale insulin only.

must be accounted for when deciding how to adjust the dose.

A reasonable strategy is to adjust basal and prandial insulin using data from the prior 24 hours, basing the basal dose on the fasting BG level and the prandial dose on the subsequent preprandial BG level (**Table**). Another common strategy is to sum all the correction doses over 24 hours and split this into basal and prandial portions based on the BG trend.

When should insulin infusions be used in the hospital?

In the critical care setting, intravenous (IV) insulin infusion is preferred as it provides a rapid onset and short duration of action that allows timely rate adjustment to meet the changing needs of the critically ill patient (10, 12, 30). Regular insulin is standard for IV infusions, and there is no advantage to using lispro or aspart (31). Insulin drips should be administered using a validated infusion protocol (10, 12). Computerized decision-support tools are increasingly being used and have been shown to improve glycemic metrics and staff compliance over paper-based insulin protocols (30).

Should noninsulin antihyperglycemic agents be used in the hospital?

In general, insulin-based regimens are recommended for management of inpatient hyperglycemia. However, data on newer agents for hospital use are accumulating, and some oral

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Table. **Example of an Inpatient Insulin Titration Algorithm***

Blood Glucose Level	*Adjustments Based on Fasting Morning Blood Glucose Level*	*Adjustments Based on Pre-lunch, Pre-dinner, or Bedtime Blood Glucose Level*
<54 mg/dL	Follow hypoglycemia protocol Reduce basal insulin by 50%	Reduce short-acting insulin dose from prior meal by 50%
<70 mg/dL	Follow hypoglycemia protocol Reduce basal insulin by 20%	Reduce short-acting insulin dose from prior meal by 20%
70–99 mg/dL	Reduce basal insulin by 10%	Reduce short-acting insulin dose from prior meal by 10%
100–180 mg/dL	No change in basal insulin	No change to insulin dose from prior meal
181–250 mg/dL	Increase basal insulin by 10%	Increase short-acting insulin dose from prior meal by 10%
>250 mg/dL	Increase basal insulin by 20%	Increase short-acting insulin dose from prior meal by 20%

** Adapted from reference 24. To convert blood glucose levels from milligrams per deciliter to millimoles per liter, multiply by 0.0555.*

agents have been evaluated in the inpatient setting.

Dipeptidyl peptidase-4 inhibitors

Dipeptidyl peptidase-4 inhibitors (DPP4is) can be safe and effective antihyperglycemic agents in select inpatients (32, 33). Because DPP4is preferentially target postprandial hyperglycemia, they can replace prandial insulin and potentially reduce workload by decreasing the number of injections (32, 33). When used alone, DPP4is carry a lower risk for hypoglycemia than basal–bolus regimens (33, 34). In addition, DPP4is can be used for patients receiving dialysis, and some (such as linagliptin) require no renal dose adjustment.

Use of DPP4is with correction scale insulin can be considered in patients with admission BG levels below 200 mg/dL or those with well-controlled T2D (HbA_{1c} level ≤7.5%) who usually use noninsulin agents at home (10–12, 32, 33). If BG values remain above the goal despite use of DPP4is, basal insulin should be added. For patients with a BG level of 200 to 300 mg/dL (11.1 to 16.7 mmol/L) on admission, moderately controlled T2D (HbA_{1c} level <9%), and preadmission insulin (TDD up to 0.5 units/kg/d), if a DPP4i is considered, it should be combined with basal insulin (11, 19).

In an RCT (Sita-Hospital), sitagliptin plus basal insulin was found to be noninferior to a basal–bolus regimen in hospitalized patients with T2D (32). The TDD of insulin was significantly lower in the sitagliptin group (24.1 vs. 34.0 units; P < 0.0001). No difference in LOS or a composite outcome of infection, acute respiratory failure, kidney injury, reoperation, and cardiovascular events was observed.

Another T2D trial randomly assigned select patients undergoing noncardiac surgery to receive linagliptin or basal–bolus insulin (33). No difference in mean daily glucose was observed, but the linagliptin group had significantly lower rates of hypoglycemia than the basal–bolus group (relative risk reduction of 86%).

If a patient's diabetes is not controlled by DPP4is plus scheduled basal and correction scale insulin, the DPP4i should be discontinued and the patient should be transitioned to a basal–bolus regimen (see the **Box**: Overview of DPP4i Use for Hospitalized Patients). Although DPP4is have not been shown to improve long-term outcomes, they can assist in management of hospitalized patients with T2D and can be switched to a different agent at or after discharge (35). Caution is advised with use of saxagliptin and alogliptin as they may increase risk for heart failure (HF). Brand-name saxagliptin is no longer produced in the United States, but as of this writing, generic saxagliptin is available.

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Overview of DPP4i Use for Hospitalized Patients

DPP4i Alone With Correction Scale Insulin

- Patients with mildly elevated BG level (180 to 200 mg/dL)
- If not at goal or if correction is >12 to 15 units/d, start low-dose basal insulin

DPP4i Plus Basal Insulin

- Patients receiving basal insulin only with postprandial hyperglycemia
- DPP4i instead of prandial insulin; covers up to 8 to 10 units of insulin per meal
- If not at goal or if correction is >12 to 15 units/d, stop DPP4i and start scheduled prandial insulin

Key Considerations

- Linagliptin can be used in renal failure and in patients receiving dialysis without dose adjustment (dose: 5 mg/d)
- Sitagliptin can be used at low eGFRs, but its efficacy at low doses may be inadequate
  - Sitagliptin dosing by eGFR:
    - ≥45 mL/min/1.73 m^2: 100 mg/d
    - 30 to 44 mL/min/1.73 m^2: 50 mg/d
    - <30 mL/min/1.73 m^2: 25 mg/d
- Avoid DPP4is in patients with a history of pancreatitis, pancreatic cancer, or biliary disease
- If continuing after discharge, confirm that DPP4is are covered by insurance

Sodium–glucose cotransporter-2 Inhibitors

Independent of improving glycemic control, sodium–glucose cotransporter-2 inhibitors (SGLT2is) have been shown to positively affect cardiovascular outcomes, HF readmissions, and progression of renal failure (12, 36–38). In select patients with HF with or without diabetes, SGLT2is can be safely used during hospitalization (10). However, they increase risk for DKA (including euglycemic DKA), hypotension, and urinary tract infection and are contraindicated in patients with T1D, those with a history of DKA, and those receiving dialysis. Inpatient SGLT2i use is discouraged in patients with poor carbohydrate intake, hypotension, sepsis, history of urinary tract infections, or indwelling foley catheters (39). In addition, SGLT2is should be held before procedures given the risk for DKA (see the Perioperative Period section) (40). When an SGLT2i is initiated, other antihyperglycemic agents often must be adjusted to prevent hypoglycemia.

Glucagon-like peptide-1 receptor agonists

Inpatient use of glucagon-like peptide-1 receptor agonists (GLP-1RAs) is not currently recommended due to their significant gastrointestinal adverse effects and increased cost (10–12, 41). The American Society of Anesthesiologists suggests that GLP-1RAs be stopped for 1 week before any scheduled procedure given reported cases of aspiration resulting from delayed gastric emptying and residual gastric contents (42). Some experts suggest mitigating this risk by prescribing a clear liquid diet in the immediate preoperative period (43). These recommendations are based on limited data and are a subject of active investigation (44).

Metformin

No prospective RCTs have evaluated metformin use in the hospital. Because metformin increases risk for lactic acidosis, it should be avoided in acutely ill hospitalized patients who are at risk for hypoperfusion, renal insufficiency, and reduced oral intake (31). For patients without renal or liver dysfunction, the addition or reintroduction of metformin can be considered, especially during the peridischarge period. The American College of Radiology does not require metformin to be held for administration of iodinated contrast nor renal function reevaluation unless the eGFR is below 30 mL/min/1.73 m^2 or the patient is undergoing an arterial catheterization study (45).

Other noninsulin agents

Sulfonylureas lead to hypoglycemia and are not recommended in the hospital (11, 31). Glinides have anecdotally

been used as an inpatient alternative to prandial insulin but increase hypoglycemia risk if not timed with a meal. Thiazolidinediones act on nuclear receptors and thus have a prolonged onset of action. They increase intravascular volume and are contraindicated in HF (31). If these drugs must be added to the patient's regimen, they should be timed close to discharge (11).

How should inpatient hypoglycemia be managed?

Hypoglycemia in hospitalized patients is an independent marker of poor outcomes. Every institution should have a nurse-driven protocol for treatment of BG levels below 70 mg/dL with oral glucose, IV dextrose, or glucagon. The protocol should also include timely BG retesting and documentation of recovery from hypoglycemia (10–12, 46). If the patient has a hypoglycemic episode or a fasting BG level below 100 mg/dL, timely adjustment of the diabetes management regimen is needed (10). Treatment for hypoglycemia should be included with every insulin order. Hospitals should track and review hypoglycemia episodes and perform root cause analyses of severe cases with poor outcomes (10). Electronic hypoglycemia prediction algorithms described in the literature reduce rates of hypoglycemia (47).

Are there contextual considerations for management of inpatient hyperglycemia?

Certain situations may significantly alter glycemic dynamics in hospitalized patients with hyperglycemia, necessitating adjustments to the insulin regimen.

Dextrose-containing IV fluids

A liter of 5% dextrose (D5W) contains 170 kcal (50 g of dextrose), and the nutrition from a continuous D5W infusion represents a small fraction of daily caloric intake compared with a regular diet. Nevertheless, dextrose-containing IV fluids directly enter the bloodstream and thus obviate any digestive requirement or incretin effect, often affecting glycemia (48, 49). Several commonly used IV medications are mixed with dextrose, including heparin, amiodarone, and certain antibiotics.

Dextrose-containing IV fluids may increase BG levels, especially in patients with uncontrolled hyperglycemia, significant insulin resistance, or T1D. Clinicians should consider switching IV solutions from dextrose to normal saline for these patients if possible.

Glucocorticoids

Systemic glucocorticoids profoundly influence glycemic control and preferentially affect postprandial glycemia (10, 50). When patients with or without diabetes receive supraphysiologic doses of glucocorticoids (≥10-mg prednisone equivalent dose [PED]), the antihyperglycemic regimen needs to be adjusted and routine POC BG checks are needed for at least the first 24 hours (12). If the patient remains euglycemic during this time, BG checks can be discontinued. In the case of mild hyperglycemia, increasing the correction scale is often sufficient to maintain glycemic control (10, 11).

Intermediate-acting glucocorticoids (prednisone or methylprednisolone) administered once daily generally affect postprandial glycemia during the day. A common strategy is administering NPH once daily with the glucocorticoid (10). Initial NPH dosing can be calculated as 0.3 to 0.5 units per milligram of the daily PED (51). Alternatively, this dose can be based on glucocorticoid dose and diabetes status, starting with 5 to 10 units of NPH for low-dose steroids and 10 to 20 units for high-dose steroids (52) (**Figure 3**). For daily intermediate-acting glucocorticoids, basal insulin may only need to be minimally adjusted as BG levels often normalize overnight. Alternatively, if the patient is on a scheduled basal–bolus insulin regimen, one strategy is to increase the prandial dose by 50% to 100% to start. A rule of thumb is that the prandial component should comprise 60% to 70% of the TDD, though this percentage may be even larger in some patients (**Figure 1**) (10,

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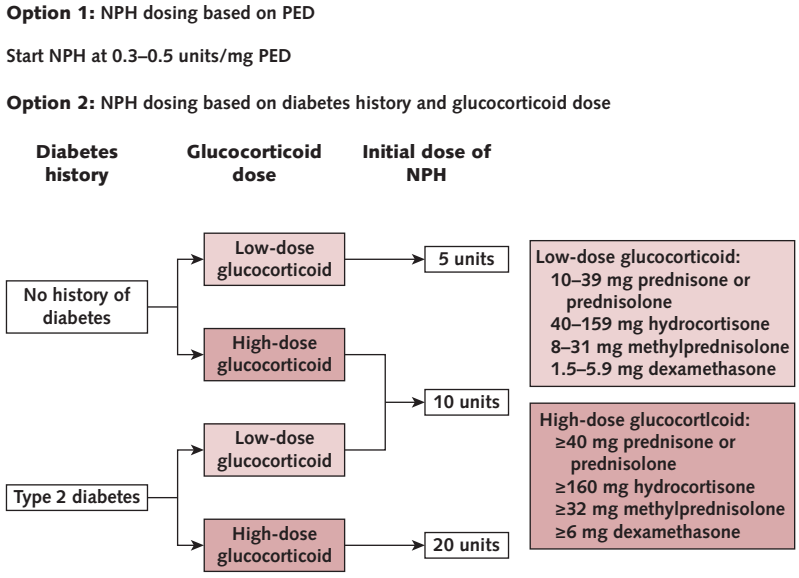
Figure 3. **Initial NPH dosing for glucocorticoid-induced hyperglycemia.**



Data from reference 49. Insulin treatment is usually indicated for patients receiving supraphysiologic doses at PED ≥10 mg. Each NPH dose should be timed with each glucocorticoid dose. If the patient is NPO, 50% of the calculated NPH dose should be given. NPH = neutral protamine Hagedorn; NPO = nil per os; PED = prednisone equivalent dose.

11). For long-acting glucocorticoids (such as dexamethasone), multiple daily doses of steroids, or PED greater than 40 mg/d, increasing the TDD with higher prandial doses (60% to 70% of TDD) is often superior to the aforementioned NPH strategy (10, 53) (**Appendix Figure 2**, available at Annals.org). Ongoing daily adjustment of insulin using previous-day correction doses is crucial to achieving and maintaining euglycemia (10, 11). Adjusting doses during steroid tapers is equally important, and one suggested strategy is for the percentage change in insulin dose to be half the percentage change in steroid dose.

Perioperative period

Patients with diabetes undergoing surgery typically need adjustments to their diabetes medications during the perioperative period. Most noninsulin medications are held on the day of the procedure; exceptions include SGLT2is, which should be held for 3 to 4 days before surgery (40), and long-acting GLP-1RAs, which should be held for at least 1 week before (42). For patients receiving insulin, long-acting insulin doses should be reduced by 20% to 25% the evening before and the morning of a procedure. Another strategy for basal insulin dosed in the morning is to give 50% of the dose before surgery and the remaining 50% after surgery, especially if the patient is restarted on a diet or enteral nutrition (EN) postoperatively. Intermediate-acting insulin doses should be reduced by 50% (10, 54). Patients with insulin pumps should have basal doses reduced or, alternatively, managed in conjunction with an endocrinologist. For prolonged liquid diets before a procedure, we suggest a 50% reduction in prandial insulin doses as liquid carbohydrates are utilized faster than those from regular meals.

What meal plan should patients with hyperglycemia follow?

For accurate hospital dosing of insulin with meals, effective communication among food service staff, nurses, and patients is necessary (55). Although no specific meal plan or macronutrient distribution is recommended for hospitalized patients, consistent carbohydrate meal plans have become the standard

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of care. Here, the quantity of carbohydrates in each meal is fixed to allow a corresponding fixed prandial insulin dose (10, 11, 55, 56). Prandial insulin dosing based on an insulin-to-carbohydrate ratio is an alternative to fixed prandial insulin dosing. It should be offered to all patients with T1D and those with T2D who use this process at home or are interested in learning. Although universal adoption of carbohydrate counting for prandial insulin dosing throughout a hospital may be limited by nursing workflow, the acute care setting provides a key educational opportunity (for example, nutritional counseling, carbohydrates listed on menus and meal tickets) (10, 11, 55, 57). Many hospitals now offer "meals on demand" with flexible meal timing and carbohydrate content. This can improve patient satisfaction and decrease costs but makes glycemic control challenging (10).

What is the best way to treat hyperglycemia in patients receiving enteral tube feeding or PN?

The prevalence of hyperglycemia in patients with and without diabetes receiving EN is approximately 30% (49, 58). Standard tube feeds have caloric distribution similar to that of oral diets, with 45% to 60% from carbohydrate, 20% to 35% from fat, and 10% to 20% from protein (59). Diabetes-specific formulas tend to be lower in carbohydrates and higher in fat and fiber. Although some studies have shown they decrease fasting BG levels, current guidelines do not recommend them over standard formulas (60, 61).

Because patients receiving continuous EN and PN are always in a postprandial state, BG targets above 140 mg/dL are appropriate and reduce risk for hypoglycemia (12). For patients with hyperglycemia who are receiving continuous EN, insulin regimens covering basal, prandial, and correctional needs achieve better glycemic control than correction scale insulin alone (10, 58). NPH administered 2 or 3 times a day plus regular correction scale insulin every 6 hours can provide adequate control (62). An alternative regimen is short-acting insulin every 4 hours (lispro or aspart) or regular insulin every 6 hours plus a correction scale and daily long-acting insulin (10, 11, 25). The long-acting insulin should only cover basal needs and not be used to cover the carbohydrate content of the feed. Therefore, it should be less than 40% of the TDD (27). Patients with T1D receiving EN should remain on basal insulin, even if tube feeding is interrupted. The NPH strategy is preferred over glargine by some as it can be adjusted more frequently. Because patients receiving EN experience nausea, vomiting, tube dislodgement, and elevated gastric residuals, regimens that can be rapidly discontinued minimize the risk for hypoglycemia (58). If the EN is stopped for more than an hour, frequent BG checks should be initiated, and an IV dextrose solution should be started when the BG level is below 180 mg/dL (10, 49, 63).

When a patient transitions from a continuous to a bolus EN feeding regimen, the TDD of insulin often needs to be reduced, even if the total caloric intake remains the same. Prandial insulin and a correction scale should be ordered before each bolus feed (10). Patients with hyperglycemia and with nocturnal feeds should receive NPH at the initiation of the tube feed (10).

PN bypasses the incretin pathway and has a 50% incidence of hyperglycemia (62, 64). The recommended strategy is "insulin in the PN bag" (10, 64, 65). This regimen has efficacy similar to that of basal–bolus regimens and minimizes hypoglycemia, as insulin delivery is simultaneously discontinued if PN infusion is interrupted (66). The major disadvantage is that the insulin dose is fixed (65, 67). Therefore, in patients whose clinical condition warrants frequent insulin adjustments, a separate insulin infusion or subcutaneous insulin is advisable (65, 68).

What is the utility of continuous glucose monitors in the hospital?

Patients who wear continuous glucose monitors (CGMs) at home may continue

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wearing them in the hospital (10–12, 46). CGM use is recommended in select inpatients at high risk for hypoglycemia as their predictive algorithms alert for impending hypoglycemia and allow for early intervention and prevention, which is particularly helpful for nocturnal hypoglycemia (10–12, 46). BG monitoring should be a hybrid, with both CGM and corroborating POC BG checks for meals, hypoglycemia, and severe hyperglycemia (10, 46). CGMs can give erroneous results in patients with hypoperfusion and with certain medications, including high-dose vitamin C, acetaminophen (>4 g/d), hydroxyurea, and dopamine (11). Certain CGMs may need to be removed for magnetic resonance imaging scans (69). Although inpatient CGM use is not currently approved for in-hospital use, it was approved by the U.S. Food and Drug Administration during the COVID-19 pandemic to limit health care worker exposure and use of personal protective equipment (12, 46, 70). With this proof of concept, adoption of in-hospital CGM use is on the horizon.

Should patients using insulin pumps as outpatients continue their use while hospitalized?

Patients using insulin pumps at home, including automated insulin delivery devices, should be able to continue using them in the hospital if they are mentally and physically able to manage them (10, 46). Institutional pump and CGM policies and order sets help standardize and clarify diabetes device processes for hospital staff. Having hospital staff with expertise in managing insulin pumps or training staff in diabetes technology is beneficial.

A diabetes specialist should be consulted early in the hospitalization, and baseline insulin pump settings should be documented and adjusted (71). Depending on the pump, the settings may include a TDD (basal and bolus), a carbohydrate ratio, and an insulin sensitivity factor (expected BG reduction from 1 unit of insulin) (71). Carbohydrate counting should be encouraged with electronic medical record documentation of insulin meal boluses given via the pump (46). Pump sites should be evaluated regularly for infection, lipodystrophy, or pump leakage (71). In cases of pump failure or inability to manage the pump, the patient should be transitioned to subcutaneous insulin injections. The total basal dose from the pump can be converted into a once-daily basal insulin injection. Prandial and correction scale insulin doses should mirror the carbohydrate and sensitivity factors, respectively (71).

When should a diabetes specialist be consulted?

Implementation of a dedicated inpatient diabetes management service has been associated with improved patient knowledge and satisfaction as well as decreased rates of hyperglycemia, hypoglycemia, LOS, postdischarge HbA_{1c} elevation, and readmission rates (11, 72). A diabetes specialist, if needed, should be involved early in the hospitalization (72). Consideration for consultation should include patient characteristics associated with greater disease severity or readmission risk, such as diabetes emergencies (for example, DKA, hyperosmolar hyperglycemic state, severe hypoglycemia), HbA_{1c} level above 9%, hospitalization within the previous 90 days, or in-hospital hypoglycemia or severe hyperglycemia (BG level ≥300 mg/dL). Other inpatients who could benefit from these teams include those with T1D, severe pancreatic pathology, poorly controlled diabetes of pregnancy, insulin pump use, use of U-500 concentrated insulin, or high total daily insulin requirements (for example, >0.8 units/kg/d).

What are best practices for hospital discharge?

The 4 pillars of a successful discharge are medications, glycemic monitoring, diabetes education, and outpatient follow-up (**Figure 4**). Most patients with diabetes who have an HbA_{1c} level below 8% on admission can resume their home regimen. However, among patients with uncontrolled diabetes (for example, HbA_{1c} level ≥8%), intensification of the

79. Boye KS, Stein D, Matza LS, et al. Timing of GLP-1 receptor agonist initiation for treatment of type 2 diabetes in the UK. Drugs R D. 2019;19:213-225. [PMID: 31115873]

Figure 4. **Discharge checklist.**

Medications	Glucose Monitoring	Diabetes Education	Follow-up
• Make appropriate adjustment to medication regimen based on preadmission HbA_{1c} level • Provide patients with printed medication reconciliation lists on discharge • Verbally review list with patient and family	• Review when and how to check blood glucose • Consider prescribing a CGM if the patient is receiving insulin or is at risk for hypoglycemia	• Definition, recognition, and treatment of hyperglycemia and hypoglycemia • Review of sick day rules • Information on making healthful food choices • Proper use and disposal of diabetes supplies	• Identification of health care provider who will provide diabetes care after discharge • Outpatient follow-up appointment within 1 month of discharge • Sooner follow-up if there are significant medication changes or if diabetes is poorly controlled

Supplies Checklist

If using insulin vials **(*each vial contains 1000 units of insulin*):**
- ❑ Insulin syringes (usually 31G, 0.5 or 1 mL)

***If using insulin pens*:**
- ❑ Pen needles (usually 32G × 4 mm)

***BG monitoring*:**
- ❑ Glucometer
- ❑ Test strips
- ❑ Lancets
- ❑ Alcohol wipes
- ❑ Consider CGM

***Other*:**
- ❑ Glucagon (preferably reconstituted or nasal)
- ❑ Glucose tablets (1 tablet is 4 g of glucose)
- ❑ Urine ketone test strips (if patient has T1D or history of DKA)
- ❑ Sharps container (optional)

Data from references 24 and 68. BG = blood glucose; CGM = continuous glucose monitor; DKA = diabetic ketoacidosis; HbA_{1c} = hemoglobin A_{1c}; T1D = type 1 diabetes.

diabetes regimen on discharge has been associated with improved glycemic control and decreased risk for early rehospitalization (73–76) (**Figure 5**). Depending on the HbA_{1c} level and patient comorbidities (for example, cardiovascular disease, chronic kidney disease), initiation of a GLP-1RA, an SGLT2i, and/or insulin should be considered at discharge. Initiation of CGM on discharge should be considered for select patients, especially those at high risk for hypoglycemia (77).

Because medication complexity and cost play an outsized role in drug nonadherence, barriers to obtaining medications should be evaluated early in the admission (75). GLP-1RAs, SGLT2is, CGMs, and certain insulins may require prior insurance authorization. Patients discharged with a new prescription for a GLP-1RA or insulin should have early follow-up as they may need frequent medication adjustments. Despite these barriers, initiation of appropriate medications on discharge can help shorten the delay in patients receiving an optimized diabetes regimen. This may significantly benefit disease trajectories, especially for patients with HF, cardiovascular disease, chronic kidney disease, or other comorbidities (78, 79).

Diabetes education empowers patients to make appropriate changes and also has been shown to reduce risk for readmission. Although diabetes education may be limited in the inpatient setting, patients should at a minimum be taught how and when to take diabetes medications, how to recognize and treat hypoglycemia and hyperglycemia, how to monitor their BG, and when to seek help. A standardized checklist should be used to ensure no necessary diabetes supplies are missed (**Figure 4**). Finally, standardized and clear communication should be sent to the patient's outpatient care team. Follow-up within 1 month of hospital discharge reduces readmission rates (10).

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Figure 5. **Discharge diabetes regimen adjustment.**

Preadmission regimen	If preadmission HbA_{1c} level <8% and no red flags*	If preadmission HbA_{1c} level 8%–9% or if red flags* are present	If preadmission HbA_{1c} level >9%
Noninsulin agents only or diet controlled	Continue home regimen on discharge	• Increase dose of noninsulin agents or add an additional noninsulin agent (preferably ≤3). • If a DPP4i is started in the hospital, consider continuing it on discharge if covered by insurance. • If noninsulin agents are already maximized, consider addition of basal insulin at 0.1 units/kg/d or 50% of hospital dose.	Consider starting either a GLP-1RA with close follow-up or basal insulin at 80% of hospital dose on discharge
Basal insulin only	Continue or restart home regimen on discharge	• Consider increasing basal insulin if fasting blood glucose allows. • Consider addition of a noninsulin agent or mealtime insulin.	Consider starting either a GLP-1RA with close follow-up or mealtime insulin on discharge
Basal–bolus insulin	Continue or restart home regimen on discharge	• Intensify insulin regimen. Consider increasing TDD by 10%–20% with further adjustments as an outpatient. • Aim to increase basal–bolus regimen to achieve or maintain a basal–bolus ratio of 50:50.	

Data from reference 24. A GLP-1RA can be considered rather than insulin at discharge if appropriate and available. Clinicians should confirm that noninsulin agents are maximized before starting or increasing insulin. Before intensifying the discharge insulin regimen, the clinician should evaluate the patient's insulin injection technique and adherence. DPP4i = dipeptidyl peptidase-4 inhibitor; GLP-1RA = glucagon-like peptide-1 receptor agonist; HbA_{1c} = hemoglobin A_{1c}; TDD = total daily dose.
* Red flags include new contraindication to one of the noninsulin agents from the prior home regimen, an insulin requirement >20 units/d when the patient was not previously using insulin at home, and an in-hospital insulin requirement >20% more than the prior home insulin requirement.

Treatment... Insulin remains the standard of care for management of hospital hyperglycemia. In most non-critically ill patients, subcutaneous basal-bolus regimens are preferred for those who are eating, and "basal-plus" regimens are preferred for those who are NPO. Patients with T1D should always receive some form of basal insulin regardless of their nutritional status. For critically ill patients, IV insulin keeps up with their dynamic clinical condition. Most noninsulin agents should be discontinued on admission; however, in select hospitalized patients, a DPP4i with correction scale insulin with or without basal insulin can be effective. SGLT2is are appropriate in certain patients with HF, excluding those at high risk for DKA. Patients with CGM and those with insulin pumps and the capacity to manage them should be able to continue using their devices in the hospital as guided by hospital policy. An inpatient diabetes management service should be involved early, and comprehensive checklists should be implemented during transitions of care.

CLINICAL BOTTOM LINE

In the Clinic
Tool Kit

Management of Hyperglycemia in Hospitalized Patients

Patient Information

https://medlineplus.gov/hyperglycemia.html
https://medlineplus.gov/languages/hyperglycemia.html
Information on hyperglycemia in English and other languages from the National Institutes of Health's MedlinePlus.

https://diabetes.org/living-with-diabetes
Information on life with diabetes from the American Diabetes Association.

www.endocrine.org/patient-engagement/endocrine-library/hyperglycemia
Patient resources on hyperglycemia from the Endocrine Society.

https://diabetes.org/living-with-diabetes/treatment-care/hyperglycemia
Information on treatment and care for hyperglycemia from the American Diabetes Association.

Information for Health Professionals

https://diabetesjournals.org/care/article/47/Supplement_1/S295/153950/16-Diabetes-Care-in-the-Hospital-Standards-of-Care
Diabetes Care in the Hospital: *Standards of Care in Diabetes–2024*, from the American Diabetes Association Professional Practice Committee.

www.endocrinepractice.org/article/S1530-891X(22)00576-6/fulltext
American Association of Clinical Endocrinology clinical practice guideline on developing a comprehensive care plan for diabetes mellitus.

https://academic.oup.com/jcem/article/107/8/2101/6605637
Endocrine Society clinical practice guideline on management of hyperglycemia in hospitalized adult patients in non–critical care settings.

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WHAT YOU SHOULD KNOW ABOUT HYPERGLYCEMIA IN THE HOSPITAL

What Is Hyperglycemia?

Hyperglycemia is the term for high blood glucose (blood sugar), which happens when the body has too little insulin or can't use insulin properly. Hyperglycemia is concerning in the hospital as it may lead to additional complications, including infection and dehydration.

If you have diabetes, let your nurse and doctor know when you enter the hospital. If possible, bring your medications and insulin (or a detailed list of all your medications and your insulin dose) to the hospital. Ask your doctor to make sure this information goes into your chart.

What May Cause Hyperglycemia in the Hospital?

Hyperglycemia in the hospital is often related to various causes, including:

- Not receiving enough insulin (especially if you have type 1 diabetes)
- Ineffective use of insulin by your body (as often occurs in type 2 diabetes)
- The body's stress response to an illness, such as a cold or flu
- Certain medications that may raise your blood sugar, such as steroids
- Having a heart attack or another serious medical condition that increases metabolic stress

What Are the Symptoms of Hyperglycemia?

Signs and symptoms include:

- High levels of glucose in the blood and urine
- Frequent urination
- Increased thirst
- Dizziness or dehydration

Can I Prevent Hyperglycemia in the Hospital?

One way to prevent hyperglycemia in the hospital is by checking your blood glucose often. If you are being admitted for a procedure, ask your doctor how often you should check and what your levels should be before or during your hospitalization. Also ask about which medications you should or should not take before a procedure.

In the hospital, your care providers will check your blood glucose and treat elevations early to avoid problems associated with hyperglycemia.

What Will Happen in the Hospital?

- Your doctor will order blood sugar testing and will monitor your levels carefully.
- Your physician will likely order insulin or other medications to treat persistently elevated blood sugars.
- Your doctor may perform or refer you for other tests.

How Is Hyperglycemia in the Hospital Treated?

Hyperglycemia in the hospital is most often treated with insulin. Basal (long- or intermediate-acting) insulin is given once or twice a day to keep blood sugar levels steady between meals or if you are not eating. The effect of these injections tends to be over 24 hours, and they should not be skipped if you do not eat, although doses may need to be adjusted if you are not eating.

Before meals, bolus (rapid-acting) insulin helps prevent blood sugar levels from going too high after eating. This scheduled insulin treatment can help prevent a dangerous health problem called diabetic ketoacidosis (DKA), where acids and substances called ketones build up in the blood due to lack of insulin.

Intravenous insulin is another option. It is used when the blood sugar is too high or unstable, when the blood sugar does not respond to subcutaneous injections, or if you have DKA. Intravenous insulin can also be used in very sick patients or those who are not able to eat.

How Should I Manage My Diabetes Before Surgery?

Before surgery, patients who take insulin should continue to do so. If you do not take insulin, your care providers will sometimes stop or adjust noninsulin medicines and may advise you to receive insulin while in the hospital.

Before and after surgery, all patients with type 1 diabetes and most with type 2 diabetes should receive insulin, especially basal insulin to prevent hyperglycemia and DKA.

Questions for My Doctor

- Does having hyperglycemia in the hospital mean I have diabetes?
- What type of diabetes do I have?
- What is the plan to manage hyperglycemia in the hospital?
- What should be my plan to manage hyperglycemia when I leave the hospital?
- What physical activities are good for me?
- Which medicines will I be taking for diabetes, and what do they do?
- What changes in my condition should make me call the office?
- Who will be managing my hyperglycemia after discharge?

For More Information

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Endocrine Society
www.endocrine.org/patient-engagement/endocrine-library/hyperglycemia

American Diabetes Association
https://diabetes.org/living-with-diabetes/treatment-care/hyperglycemia

Patient Information

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Appendix Table. **Insulin Subtypes**

Insulin	*Onset*	*Peak*	*Duration*
Rapid-acting insulin (lispro, aspart, glulisine)*	5–15 min	45–90 min	2–4 h
Short-acting insulin (regular)†	30 min	2–5 h	4–8 h
Intermediate-acting insulin (NPH)	1–3 h	4–10 h	10–18 h
Long-acting insulin (glargine)	Onset within 2–3 h, and continues at a constant level for ≥20–24 h		

NPH = neutral protamine Hagedorn.
** May need to take 5 to 15 min before meal.*
† Take 15 to 30 min before meal.

Appendix Figure 1. **Case example: strategies for initial insulin dosing in the hospital.**

Example 1: Weight-Based Approach

A 40-year-old, 115-kg patient with T2D on a regimen of metformin and glargine, 45 units each night, without any mealtime insulin is admitted for postoperative monitoring after scheduled surgery. His admission HbA_{1c} level is 8%, and his fasting BG level is 191 mg/dL.
The patient is cleared to eat and has stated that he currently has a good appetite.
TDD = weight (kg) × 0.4 units/kg = 115 kg × 0.4 units/kg = 46 units
Inpatient basal insulin = 46 units × 1/2 = 23 units
Inpatient prandial bolus insulin = 46 units × 1/2 × 1/3 = ~8 units TID with meals
Add moderate-intensity ICS

Summary: Given that this patient's admission HbA_{1c} level is <9% and his initial BG level is <200 mg/dL, his diabetes is relatively well controlled on his home regimen. However, the fact that he does not meet an HbA_{1c} target of 7% suggests that some of his prandial glycemic control is being accomplished by the basal insulin. In hospitals that allow for prorated prandial insulin dosing with meals, it would be prudent to specify 4 units with half a meal in addition to the 8 units with the full meal.

Example 2: Insulin Before Admission

A 72-year-old, 92-kg patient with a history of T2D who uses insulin at home and has an HbA_{1c} level of 7.5% is admitted for sepsis secondary to acute pyelonephritis and acute kidney injury. Her home regimen is glargine, 16 units each night, and semaglutide, 1 mg per week. Her BG level at admission is 215 mg/dL. Her "effective" home TDD is basal × 2 = 16 units × 2 = 32 units.
Inpatient TDD = home TDD × 0.75 = 32 units × 0.75 = 24 units
Inpatient basal insulin = inpatient TDD × 1/2 = 24 units × 1/2 = 12 units
Inpatient prandial insulin = inpatient TDD × 1/2 × 1/3
= 24 units × 1/2 × 1/3
= 4 units TID with meals
Add low-intensity ICS

Summary: This patient has many risk factors for hypoglycemia, including advanced age, acute illness, reduced renal function, and decreased appetite. Her diabetes is well controlled, and her BG level is mildly elevated at admission. Based on these factors, we will want to decrease her inpatient insulin dose by 25% from her prior home regimen.

BG = blood glucose; HbA_{1c} = hemoglobin A_{1c}; ICS = insulin correction scale; T2D = type 2 diabetes; TDD = total daily dose; TID = 3 times a day.

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Appendix Figure 2. **Case example: strategies for initial insulin dosing for patients receiving corticosteroids.**

Example 3: Insulin Before Admission and Initiation of Systemic Steroids

A 36-year-old, 75-kg patient with T2D and an HbA_{1c} level of 9% is admitted for an acute asthma exacerbation and is started on prednisone, 40 mg daily. His home regimen is glargine, 10 units each night, and lispro, 5 units with each meal. His home TDD is 25 units. His BG level at admission is 250 mg/dL.

Inpatient basal insulin = weight (kg) × 0.2 units/kg = 75 kg × 0.2 units/kg
= 15 units daily
Inpatient bolus doses = home bolus × 150% = 5 units × 150%
= 7.5 units
~8 units TID with meals
Start moderate-intensity ICS

This results in a TDD of 39 units, which represents an increase in the home TDD of ~60% and a basal–bolus ratio of ~40:60.

Summary: This patient has poorly controlled diabetes, his BG level is elevated at admission, and he is starting high-dose steroids. Although his home TDD is 25 units, given that his HbA_{1c} level and admission BG level are not at target, it is likely that his basal dose is too low and needs to be increased. In addition, because of the steroids, we also increased his bolus insulin doses to achieve a basal–bolus ratio of 40:60. The patient should be monitored closely, and his insulin should be adjusted daily.

Example 4: Systemic Steroids With No Baseline Insulin Requirement

A 67-year-old, 80-kg patient with a history of diet-controlled T2D (HbA_{1c} level of 6.5%) is admitted for an acute asthma exacerbation and is started on prednisone, 40 mg daily. His BG level on hospital day 1 is 120 mg/dL before breakfast, 250 mg/dL before lunch, 280 mg/dL before dinner, and 150 mg/dL before bedtime.

Start NPH every morning at a dose of 0.4 units/mg PED
Inpatient NPH dose = 0.4 units/mg × PED
= 0.4 units/mg × 40 mg
= 16 units daily
Start moderate-intensity ICS

Summary: This patient has well-controlled diabetes at baseline but has steroid-induced hyperglycemia in the hospital, primarily affecting midday glucose levels. A morning dose of NPH, given along with the morning steroid, is preferred as the timing of the peak of action of NPH coincides with the timing of the hyperglycemia.

BG = blood glucose; HbA_{1c} = hemoglobin A_{1c}; ICS = insulin correction scale; NPH = neutral protamine Hagedorn; PED = prednisone equivalent dose; T2D = type 2 diabetes; TDD = total daily dose; TID = 3 times a day.

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